CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD

TECHNICAL SUPPORT DOCUMENT FOR
STAFF PROPOSAL REGARDING REDUCTION OF GREENHOUSE GAS EMISSIONS FROM MOTOR VEHICLES

ECONOMIC IMPACTS OF THE CLIMATE CHANGE REGULATIONS

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Economic Impacts of the Climate Change Regulations

Assembly Bill 1493 requires the ARB to "develop and adopt, by January 1, 2005, regulations, effective January 1, 2006, that achieve maximum feasible and cost-effective reduction of greenhouse gases emitted by passenger vehicles and light-duty trucks" and other noncommercial personal vehicles, beginning in 2009. This landmark bill recognizes the importance of mitigating climate change by limiting emissions of greenhouse gases from motor vehicles. Cars and trucks account for over 40 percent of CO2 emissions in California. The control and mitigation of climate change will have substantial positive economic impacts on California in many areas such as public health, water supply, agricultural productivity, environmental degradation, and catastrophic natural disasters.

The bill also requires that climate change regulations must consider the impacts on the economy of the state. The consideration should include, but not be limited to, the impacts of the regulations on the creation, elimination, and expansion of jobs and businesses, California business competitiveness. The regulations must take into account the impacts on local communities with minority populations or low-income populations, and California automobile workers and affiliated businesses.

This technical document discusses the economic methodology and impacts we anticipate from implementation of the proposed climate change regulations on the California economy. The results are intended to provide an overall picture of the economic impacts of the proposed regulations on the economy. We recognize that individual businesses and consumers may experience different impacts than anticipated.

This document also presents economic impacts on households in communities that are significantly exposed to air contaminants, also known as environmental justice communities.

1. Legal Requirements

The legal requirements for economic analysis are included in the Government Code and the Health and Safety Code. This section explains the requirements that must be satisfied for economic analyses of the proposed regulations.

Section 11346.3 of the Government Code, which applies to all agencies statewide and predates AB 1493, requires State agencies to assess the potential adverse economic impacts on California business enterprises and individuals when such agencies propose to adopt or amend any administrative regulation. The assessment shall include a consideration of the impact of the proposed regulation on California jobs, business expansion, elimination or creation, and the ability of California business to compete with businesses in other states. Health and Safety Code section 43018.5(c)(2), added by AB 1493, repeated many of these criteria. That section also added two criteria specific

to this regulation, namely, to evaluate economic impacts on the State's automotive workers and affiliated businesses, and on minority and low income communities.

State agencies also are required to estimate the cost or savings to any State or local agency and school district, in accordance with instructions adopted by the Department of Finance (DOF). The estimate shall include any non-discretionary cost or savings to local agencies and the cost or savings in federal funding to the State.

Finally, Health and Safety Code section 57005 requires the Air Resources Board to perform an economic impact analysis of submitted alternatives to a proposed regulation before adopting any major regulation. A major regulation is defined as a regulation that will have a potential cost to California business enterprises in an amount exceeding ten million dollars in any single year.

2. Potential Impacts on Business Creation, Elimination, or Expansion

The climate change regulation affects only light duty vehicles whose primary use is noncommercial personal transportation. Therefore, many vehicles that businesses use would not be covered under the proposed regulations. However, if the businesses purchase the same vehicles as consumers, they would be expected to pay higher prices for the vehicles but save on operating costs, as is discussed in the ISOR. As noted in the ISOR, staff expects that reduced operating costs will more than outweigh the effect of the increase in price over the life cycle of the vehicle.

It is very likely that savings from reduced vehicle operating costs would end up as expenditures for other goods and services. These expenditures would flow through the economy, causing expansion or creation of new businesses in several sectors. It is also possible that some sectors of the economy such as fuel producers, distributors, and retailers will be adversely impacted. However, the staff analysis shows that such impacts are more than offset. Staff's economic analysis shows that as the expenditures occur, jobs and personal income increase. Jobs increase by 3,000 in 2010, by 55,000 in 2020, and 83,000 in 2030 compared to the baseline economy that excludes the proposed regulations. Similarly, income grows by $160 million in 2010, by $5.3 billion in 2020, and $8.5 billion 2030.

The E-DRAM model was used to assess the overall impact of the regulation on California's economy. Specifically, E-DRAM was used to estimate impacts on California's output of goods and services, personal income, and employment. The estimates of the regulation's impact on these economic factors are used to assess the potential impacts on business creation, elimination, or expansion in California. The next section describes E-DRAM.

2.1 Compliance Cost Estimates

Staff estimates that the proposed near-term (2009-2012) regulations would increase the average retail prices of passenger cars (PC) and small trucks (T1) from $16 to $292, and large trucks (T2) from $36 to $308. In the mid-term (2013-2016) the price increases for PC/T1 vehicles as compared to the 2009 baseline would range from $330 to $626, and for T2 vehicles would range from $382 to $955. The incremental retail prices for all affected vehicles would remain unchanged after 2016.

These price increases are expected to be passed on to consumers in one form or another. This section annualizes these costs and estimates the corresponding operating cost savings for an analysis of impacts on the California economy. The net impact of vehicle price increases on consumers is discussed later in this section.

The new PC/LDT1 vehicles are expected to have a median life of 16 years with the LDT2 vehicles expected to have a median life of 19 years. During their life, the vehicles will provide transportation at lower operating costs, a benefit. To match the costs to the 16 years of benefits, we annualized the costs over the life of the vehicles. Annualized costs are estimated using a real discount rate of five percent based on an average of the past ten-year interest rates on car loans. Table 1 provides estimates of total annualized costs of the proposed climate change regulations from 2009 to 2030. The total cost was derived by multiplying new vehicle sales by the average cost increase per vehicle. The total costs to consumers vary each year from 2009 to 2030. Annualized costs of the proposed regulations are estimated to be approximately $12 million in 2010, $834 million in 2020, and about $1.7 billion in 2030. The annualized cost increases over time, due to additional sales of new cars at the higher price as multiple model years are annualized over the same period. For example, the annualized cost in 2011 of $40 million reflects the annualized costs of model years 2009, 2010, and 2011. Thus, the annualized costs for each year are for cumulative sales of new cars since 2009. The $834 million in annualized cost in 2020 represents the cost, in 2020, of all complying vehicles sold from 2009 through 2020. The new vehicle sales totals are based on projected numbers of vehicles sold in that year as forecast by the EMFAC model.

Table 1. Estimates of Total Annual Costs of the Proposed Climate Change Regulations for 2009 through 2030 (millions of 2004 Dollars)

Model Year	Annualized Costs to Consumers of PC/T1	Annualized Costs to Consumers of T2	Incremental Annualized Costs to Consumers of MY 2009+ Vehicles	Cumulative Annualized Cost
2009	$ 2	$ 1	$ 3	$ 3
2010	$ 6	$ 3	$ 9	$ 12
2011	$ 23	$ 6	$ 29	$ 40
2012	$ 35	$ 9	$ 44	$ 84
2013	$ 39	$ 11	$ 50	$ 135
2014	$ 46	$ 15	$ 61	$ 196
2015	$ 59	$ 23	$ 82	$ 279
2016	$ 77	$ 30	$ 107	$ 386
2017	$ 78	$ 31	$ 109	$ 495
2018	$ 80	$ 32	$ 112	$ 606
2019	$ 81	$ 32	$ 113	$ 719
2020	$ 82	$ 33	$ 115	$ 834
2021	$ 80	$ 32	$ 112	$ 947
2022	$ 82	$ 33	$ 115	$ 1,061
2023	$ 83	$ 33	$ 116	$1,178
2024	$ 85	$ 33	$ 118	$ 1,296
2025	$ 86	$ 34	$ 120	$ 1,413
2026	$ 87	$ 35	$ 122	$ 1,527
2027	$ 89	$ 37	$ 126	$ 1,621
2028	$ 90	$ 38	$ 128	$ 1,682
2029	$ 92	$ 39	$ 131	$ 1,704
2030	$ 93	$ 40	$ 133	$ 1,676

Source: Sales data from ARB EMFAC model.

Many of the technologies that reduce climate change emissions will also reduce the operating costs of vehicles. Lifetime maintenance costs are also expected to remain the same or decline, depending on the technologies chosen by manufacturers. For example, improved containment of air conditioning refrigerant may reduce the need for mobile air conditioning servicing and therefore reduce maintenance costs to consumers. Due to a lack of comprehensive data, however, staff assumed no change in maintenance costs for the purpose of this analysis.

Estimates of the average reduction in operating costs of the new vehicles range from about 1 percent to 21 percent for PC/LDT1, and about 2 percent to 26 percent for LDT2. Table 2 provides estimates of annual operating cost savings from 2009 through 2030. Data used to derive estimated reductions in operating costs are generated from the EMFAC model. The analysis assumes a gasoline price of $1.74 per gallon, taken from the 2004 California Energy Commission (CEC) Integrated Energy Policy Report. As

shown in Table 2, for every dollar of the cost, the regulations could save $5 to $11 savings for the consumers.

Table 2. Estimates of Total Annual Value of New Vehicle Operating Cost Savings (millions of 2004 Dollars)

Model Year	Annual Fuel Savings (millions of gallons)	Operating Cost Savings	Saving to Cost Ratio
2009	16	$27	9.2
2010	71	$124	10.3
2011	239	$415	10.4
2012	529	$921	11.0
2013	808	$1,407	10.5
2014	1,101	$1,913	9.8
2015	1,418	$2,464	8.9
2016	1,749	$3,050	7.9
2017	2,080	$3,620	7.3
2018	2,400	$4,172	6.9
2019	2,701	$4,706	6.5
2020	2,997	$5,223	6.2
2021	3,298	$5,734	6.0
2022	3,562	$6,194	5.8
2023	3,814	$6,635	5.6
2024	4,052	$7,055	5.4
2025	4,279	$7,451	5.3
2026	4,551	$7,913	5.2
2027	4,766	$8,286	5.1
2028	4,966	$8,640	5.1
2029	5,158	$8,976	5.2
2030	5,348	$9,292	5.5

Overall, purchasers of new vehicles in 2009 and beyond would experience a significant reduction in their operating costs.

3. Consumer Expenditures and Savings

This section provides the details of the cost calculations used for the E-DRAM economic impact analysis. Table 3 shows the costs of control in terms of increased annual consumer expenditures for the PC/LDT1 and LDT2.

Table 3. PC/LDT1 and LDT2/T3 Sales, and Cost of Control (2004$)

Model	PC/LDT1 Vehicles			LDT2/T3 Vehicles		
	Sales	Average Cost	Increased Expenditures	Sales	Average Cost	Increased Expenditures
2009	1,278,614	16	20,457,824	330,469	36	11,896,884
2010	1,302,903	52	67,750,956	343,767	93	31,970,331
2011	1,282,766	194	248,856,604	344,740	199	68,603,260
2012	1,285,276	292	375,300,592	351,126	308	108,146,808
2013	1,296,618	330	427,883,940	361,633	382	138,143,806
2014	1,312,963	383	502,864,829	371,389	491	182,351,999
2015	1,331,944	483	643,328,952	381,317	723	275,692,191
2016	1,327,091	626	830,758,966	384,131	955	366,845,105
2017	1,354,192	626	847,724,192	393,942	955	376,214,610
2018	1,378,927	626	863,208,302	402,109	955	384,014,095
2019	1,400,625	626	876,791,250	407,622	955	389,279,010
2020	1,424,893	626	891,983,018	413,410	955	394,806,550
2021	1,393,349	626	872,236,474	402,458	955	384,347,390
2022	1,421,991	626	890,166,366	412,577	955	394,011,035
2023	1,445,042	626	904,596,292	417,925	955	399,118,375
2024	1,464,559	626	916,813,934	422,645	955	403,625,975
2025	1,480,373	626	926,713,498	425,586	955	406,434,630
2026	1,503,685	626	941,306,810	441,291	955	421,432,905
2027	1,534,331	626	960,491,206	463,445	955	442,589,975
2028	1,561,563	626	977,538,438	479,295	955	457,726,725
2029	1,588,719	626	994,538,094	490,922	955	468,830,510
2030	1,610,331	626	1,008,067,206	501,337	955	478,776,835

3.1 Annual Direct Costs to Consumers

The incremental consumer expenditures to purchase new vehicles beginning with model year 2009 and thereafter are incurred as a lump sum. Since the vehicles last for several years, the lump sum expenditure is not a cost for the year in which it was purchased. It needs to be spread over the life of the vehicle. Capital recovery method, also known as amortization method, is one way to spread the costs over life of a vehicle at a specified interest rate. The following formula is used to calculate the annualized (equivalent annual) cost of vehicle replacement:

$$AC = (ICE)(CRF)$$

Where,

AC = Annualized cost of vehicle replacement

ICE = Incremental consumer expenditure for vehicle purchase

CRF = Capital recovery factor = [i (1 + i) ^n] / [(1 + i) ^(n – 1)]

Note that "i" in the CRF formula represents the interest rate (or "opportunity cost") for the incremental consumer expenditure, while "n" represents the vehicle life, and "^" is exponent symbol. By using the capital recovery factor method, we not only account for annual depreciation expense of a vehicle but also the opportunity cost of the incremental consumer expenditures for the new vehicles.

Using the capital recovery factor method, we estimated annualized costs of the proposed regulations to consumers to be approximately $12 million in 2010, $834 million in 2020, and $1.7 billion in 2030. Table 2 provides estimates of total annual direct costs of the proposed climate change regulations to consumers from 2009 to 2030. Annual Sales Values of the vehicles were calculated by multiplying sales projection for each year by the increase in the average retail price equivalent (RPE) of vehicles in that year. The vehicle sales represents projected number of vehicles sold in that year generated from the ARB's EMFAC model. This projection is based on the assumption of the baseline scenario that vehicle prices in real terms remain flat[1].

Annualized costs to consumers are estimated using a real interest rate (opportunity cost) of 5 percent based on an average of the past ten-year interest rates on car loans and the median vehicle life of 16 years for PC/LDT1 and 19 years for T2/T3.

[1]For a complete description of vehicle climate change technology and cost assessment, please see "Draft Technology and Cost Assessment for Proposed Regulations to Reduce Vehicle Climate Change emissions," California Air Resources Board.

Table 4. Estimates of Total Annualized Costs of the Proposed Climate Change Regulations for 2009 through 2030 (2004 Dollars)

Model	PC/LDT1	LDT2/T3	PC/LDT1 and T2/T3	Cumulative*
2009	1,887,642	984,408	2,872,050	2,872,050
2010	6,251,374	2,645,385	8,896,759	11,768,809
2011	22,961,976	5,676,577	28,638,553	40,407,363
2012	34,628,951	8,948,609	43,577,560	83,984,922
2013	39,480,812	11,430,711	50,911,523	134,896,445
2014	46,399,291	15,088,718	61,488,009	196,384,454
2015	59,359,903	22,812,153	82,172,056	278,556,511
2016	76,654,053	30,354,602	107,008,655	385,565,166
2017	78,219,433	31,129,882	109,349,315	494,914,481
2018	79,648,151	31,775,250	111,423,401	606,337,882
2019	80,901,448	32,210,896	113,112,344	719,450,226
2020	82,303,191	32,668,272	114,971,463	834,421,689
2021	80,481,179	31,802,829	112,284,008	946,705,697
2022	82,135,569	32,602,447	114,738,016	1,061,443,713
2023	83,467,017	33,025,054	116,492,071	1,177,935,783
2024	84,594,337	33,398,035	117,992,373	1,295,928,156
2025	85,507,769	33,630,438	119,138,207	1,413,178,721
2026	86,854,293	34,871,470	121,725,763	1,526,765,468
2027	88,624,435	36,622,112	125,246,547	1,620,911,024
2028	90,197,382	37,874,603	128,071,984	1,682,268,657
2029	91,765,938	38,793,385	130,559,324	1,703,987,433
2030	93,014,268	39,616,394	132,630,663	1,675,701,678

* Beginning 2025 the accumulation is net of vehicles that have operated for 16 years, the assumed life of a vehicle, i.e., the total annualized cost in 2025 excludes the 2009 model year annual cost for PC/T1, 2026 excludes the 2009 and 2010 costs. Beginning 2028 when T2/T3 vehicles are 19 years old, the cumulative cost is adjusted similar to PC/T1 approach.

3.2 Operating Costs Reductions

Many of the technologies that reduce climate change emissions will also have the potential to lower the operating costs of vehicles. Lifetime maintenance costs are also expected to remain the same or decline, depending on the technologies chosen by manufacturers. For example, improved containment of air conditioning refrigerant may reduce the need for mobile air conditioning servicing and therefore reduce maintenance costs to consumers. Due to a lack of comprehensive data, however, staff assumed no change in maintenance operating costs for the purpose of this analysis. Estimates of the reduction in fuel consumption of vehicles range from about 1 percent to 21 percent for PC/LDT1, and about 2 percent to 26 percent for LDT2/T3. Table 3 provides estimates of annual fuel consumption savings from 2009 through 2030. Data on fuel consumption are generated from the EMFAC model. Fuel prices adjusted for inflation are derived from the 2004 California Energy Commission (CEC) Integrated Energy

Policy Report[2]. The value of fuel consumption savings is estimated by multiplying annual reduction in fuel consumption by a gasoline price of $1.74 per gallon. This represents the total direct savings to consumers.

Table 5. Daily PC/LDT1 and LDT2/T3 Gasoline Consumption Reductions

Year	PC/T1 Daily Gasoline Consumption 2009-2030 vintages, baseline (gallons/day)	T2/T3 Daily Gasoline Consumption 2009-2030 vintages, baseline (gallons/day)	PC/T1 Reduction in Gasoline Consumption (gallons/day)	T2/T3 Reduction in Gasoline Consumption (gallons/day)	Total Reduction in Gasoline Consumption (gallons/day)
2009	2,688,500	976,370	29,574	13,669	43,243
2010	5,307,790	1,917,850	132,695	61,371	194,066
2011	7,810,750	2,821,560	484,267	169,294	653,560
2012	10,114,620	3,665,840	1,112,608	337,257	1,449,865
2013	12,337,010	4,495,330	1,714,844	498,982	2,213,826
2014	14,482,630	5,311,230	2,346,186	669,215	3,015,401
2015	16,545,370	6,115,160	3,027,803	856,122	3,883,925
2016	18,498,930	6,891,430	3,736,784	1,054,389	4,791,173
2017	20,379,580	7,652,010	4,442,748	1,254,930	5,697,678
2018	22,177,480	8,396,820	5,122,998	1,452,650	6,575,648
2019	23,899,300	9,116,380	5,759,731	1,640,948	7,400,680
2020	25,545,100	9,811,670	6,386,275	1,824,971	8,211,246
2021	27,194,290	10,513,380	7,016,127	2,018,569	9,034,696
2022	28,593,130	11,130,730	7,577,179	2,181,623	9,758,803
2023	29,910,720	11,721,340	8,105,805	2,344,268	10,450,073
2024	31,145,490	12,286,770	8,596,155	2,506,501	11,102,656
2025	32,281,450	12,817,590	9,071,087	2,653,241	11,724,329
2026	33,677,580	13,506,210	9,631,788	2,836,304	12,468,092
2027	34,691,540	14,071,300	10,060,547	2,997,187	13,057,734
2028	35,649,350	14,626,080	10,445,260	3,159,233	13,604,493
2029	36,567,150	15,172,870	10,823,876	3,307,686	14,131,562
2030	37,442,640	15,708,370	11,195,349	3,455,841	14,651,191

[2] California Energy Commission, Integrated Energy policy Report, Fuel Division, 2004.

Table 6. Estimates of Total Annual Value of Vehicle Fuel Consumption Savings

Model Year	Annual Fuel Consumption Savings for PC/T1 (Gallons)	Annual Fuel Consumption Savings for T2/T3 (Gallons)	Annual Value of Fuel Consumption Savings ($1.74 per gallon, millions of 2004$)
2009	10,794,328	4,989,251	$27
2010	48,433,584	22,400,488	$124
2011	176,757,273	61,792,164	$415
2012	406,101,993	123,098,907	$921
2013	625,918,202	182,128,295	$1,407
2014	856,357,912	244,263,468	$1,913
2015	1,105,147,989	312,484,676	$2,464
2016	1,363,926,109	384,851,908	$3,050
2017	1,621,603,181	458,049,319	$3,620
2018	1,869,894,226	530,217,199	$4,172
2019	2,102,301,925	598,946,166	$4,706
2020	2,330,990,375	666,114,276	$5,223
2021	2,560,886,289	736,777,670	$5,734
2022	2,765,670,499	796,292,424	$6,194
2023	2,958,618,869	855,657,820	$6,635
2024	3,137,596,663	914,872,894	$7,055
2025	3,310,946,919	968,433,012	$7,451
2026	3,515,602,576	1,035,250,997	$7,913
2027	3,672,099,509	1,093,973,219	$8,286
2028	3,812,519,736	1,153,120,147	$8,640
2029	3,950,714,886	1,207,305,266	$8,976
2030	4,086,302,516	1,261,382,111	$9,292

4. Impacts on the California Economy

Higher vehicle prices provide a means to estimate the direct expenditures that will be incurred by California businesses, governments, and individuals to meet the requirements of the proposed climate change regulations. These expenditures would in turn bring about additional (indirect) changes in the California economy that may change the overall costs of the regulations to the economy. Increased vehicle prices, for example, may result in a reduction of demand for other goods and services as consumers use more of their money to pay for the price increase. California firms may respond by cutting back production and decreasing employment. On the other hand, in response to the proposed regulations automobile manufacturers are expected to choose technologies that reduce vehicle operating costs, leaving consumers with additional money to spend on products and services. This would, in turn, induce firms

supplying those products and services to expand their production and increase their hiring of workers. A third type of effect occurs when purchase of the new vehicles directly lowers demand for the petroleum refining and gasoline distribution sectors.

The changes caused by the proposed regulations will affect industries both negatively and positively. The net effect on the California economy of these activities hinges on the extent to which products and services are obtained locally. Using the E-DRAM model, staff estimated the net effects of these activities on affected industries and the overall economy. The California industries and individuals affected most by the proposed climate change regulations are those engaged in the production, distribution, sales, service, and use of light-duty passenger vehicles, as well as the refining and distribution of gasoline.

The economic model, however, does not account for the environmental improvement benefits to California businesses and citizens that the climate change regulations will bring. We believe that California actions to reduce climate change emissions, especially if followed by other states and nations, will diminish the potential of consequences from global warming in many areas such as public health, water supply, agricultural productivity, environmental degradation, and catastrophic natural disasters.

4.1 Environmental-Dynamic Revenue Analysis Model

The overall impact of all direct and indirect economic effects that may result from potential regulations developed under AB 1493 will be estimated using a computable general equilibrium (CGE) model of the California economy. A CGE model simulates various economic relationships in a market economy where prices and production adjust in response to changes caused by regulations to establish the equilibrium in markets for all goods and services and factors of production (i.e., labor and capital).

The CGE model that will be used for this analysis is a modified version of the California Department of Finance's Dynamic Revenue Analysis Model (DRAM).[3] The new modified model is called Environmental-DRAM (E-DRAM).[4] E-DRAM describes the relationships among California producers, California consumers, government, and the rest of the world. Changes to the model enable it to assess the economic impacts of large-scale environmental regulations. The economic impact results will be estimated in terms of changes in the State output, personal income, and employment.

As stated above, E-DRAM is an extended version of DRAM and contains additional detail about the California economy. The current version of the model consists of over 1,000 equations designed to capture the interactions between over 100 industrial sectors, 2 factor sectors (labor and capital), 9 consumer good sectors, 7 household

[3] For a complete description of DRAM, see Peter Berck, E. Golan and B. Smith, "Dynamic Revenue Analysis for California", California Department of Finance, Summer 1996.
[4] Berck, Peter, "Developing a Methodology for Assessing the Economic Impacts of Large Scale Environmental Regulations", Prepared for California Air Resources Board, February 2000.

sectors (classified by income level), 1 investment sector, and 45 government sectors (8 federal, 21 State, and 8 local), and the rest of the world.

Data for the industrial sectors originated with the Bureau of Economic Analysis of the U.S. Department of Commerce, based on the Census of Business – a detailed survey of companies conducted in the U.S. every five years. The conversion of national data to updated California data is accomplished by Impact Analysis for Planning (IMPLAN), a program that primarily utilizes state-level employment data to scale national-level industrial data down to the size of a state.

In much the same way as firms, households are also aggregated. California households were divided into categories based upon their taxable income. There are seven such categories in the model, each one corresponding to a California personal income tax marginal tax rate (0, 1, 2, 4, 6, 8, and 9.3 percent). Thus, the income for the "one-percent" household is calculated by adding up the income from all households in the one-percent bracket.

Similarly, the expenditure of the one-percent household on agricultural goods is calculated by adding up all expenditures on agricultural goods for these households. The total expenditure on agricultural goods is found by adding the expenditure of all households together.

Firms and households relate through factor markets and goods-and-services markets. Firms sell goods and services to households on the good-and services markets. Households sell labor and capital services to firms on the factor markets. There is a price in each of factor and goods-and services markets. Equilibrium in the factor markets and the goods-and-services markets means that prices adjust in response to changes caused by regulations to equate quantities supplied and demanded in all markets.

4.2 Producers and Households

Fundamental to the California economy, and hence E-DRAM, are the relationships between the two principal types of economic agents – producers and households.

Producers, also known as firms, are aggregated into industrial sectors, and each sector is modeled as a competitive firm. For instance, the output of all of California's agricultural firms is modeled as coming from a single entity, the agriculture sector. Each sector takes the price that it receives for its output and the prices that it pays for its inputs (capital and labor, called "factors of production," and other inputs, called "intermediate goods") as fixed. This is the competitive model: producers do not believe that their decisions have any effect on prices. Each producer is assumed to choose inputs and output to maximize profits. Inputs are labor, capital, and intermediate goods (outputs of other firms). Thus, the producer's supply of output is a function of price and the producer's demand for inputs is a function of price.

Households make two types of decisions: they decide to buy goods and services; they also decide to sell labor and capital services. They are assumed to make these decisions in the way that maximizes their happiness (called "utility" in the economics literature). Like firms, they take the prices of the goods that they buy and the wage of the labor that they sell as fixed. In addition to their labor income, households receive dividends and interest from their stocks and bonds and other ownership interests in capital.

Households' supply of labor, as a function of the wage rate, is called the "labor-supply function." Households' demand for goods or services, as a function of prices, is simply called the "demand function." A more detailed description of the demand for goods and services is given in *"Estimation of Household Demand for Goods and Services in California's Dynamic Revenue Analysis Model,"* (Berck, Hess, and Smith, Sept. 1997) currently available at www.are.berkeley.edu/~phess/demand.pdf. The latter explains how the distribution of household spending across the 29 industrial sectors via the nine consumer goods sectors is based on analysis of U.S. Bureau of Labor Statistics' Consumer Expenditure Survey data.

4.3 Equilibrium

So far, two types of agents have been described: firms and households. It remains to be explained how these agents relate. They relate through two types of markets: factor markets and goods-and-services markets. Firms sell goods and services to households on the goods-and-services markets. Households sell labor and capital services to firms on the factor markets. There is a price in each of these markets. There is a price for the output of each of the 29 industrial sectors. There is a price for labor, called the "wage," and a price for capital services, called the "rental rate." Equilibrium in a market means that the quantity supplied (which is a function of price) is equal to the quantity demanded (which is also a function of price) in that market. Equilibrium in the factor markets for labor and capital and in the goods-and-services markets for goods and services defines a simple general equilibrium system. That is, there are 31 prices (the wage, the rental rate, and one for each of the 29 goods made by the 29 sectors) and these 31 prices have the property that they equate quantities supplied and demanded in all 31 markets. They are market-clearing prices.

These relationships are shown in more detail in the Figure 1 below, called a "circular-flow diagram." The outer set of flows, shown as solid lines, are the flows of "real" items, goods, services, labor, and capital. The inner flows, shown as broken lines, are monetary flows. Thus, firms supply goods and services to the goods-and-services market in return for revenues that they receive from the goods-and-services markets. Firms demand capital and labor from the factor markets and in return pay wages and rents to the factor markets.

Households, the other type of agent in a simple model, buy, or in economic parlance, demand, goods and services from the goods-and-services markets and give up their expenditure as compensation. They sell capital and labor services on the factor markets and receive income in exchange.

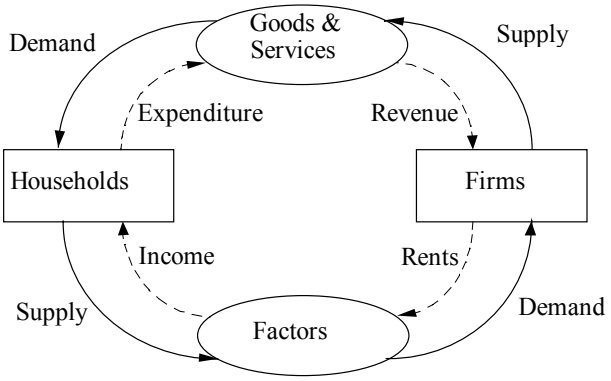

Figure 1. The Basic Circular-Flow Diagram

4.4 Intermediate goods

The economy of California is far more complex than that shown in Figure 1 above. There are not only final goods-and-services markets but also intermediate goods markets in which firms sell to firms. A typical example of this would be chemicals sold to agricultural firms. The final output of the chemical industry (perhaps fertilizer) is said to be an intermediate good in the agricultural industry. This type of market is demonstrated in Figure 2 below. Here, part of the supply of a firm (chemical industry in the example) is not sold to households but rather to another firm in exchange for revenue. From the other firm's point of view, it buys an input to production from a firm rather than from a household. The expense of buying the input is a cost of production.

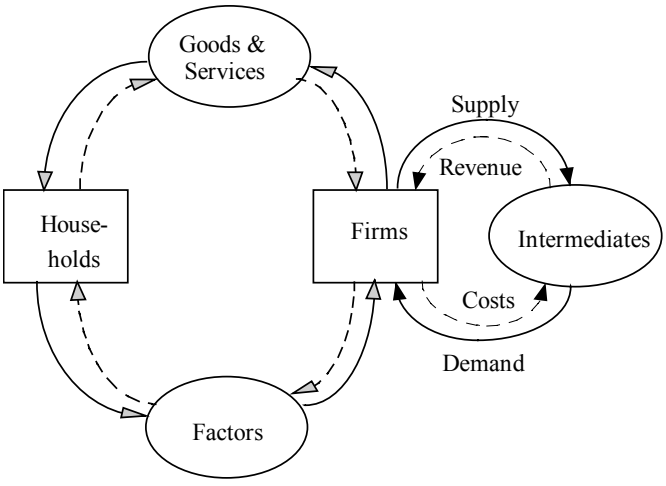

Figure 2. The Circular-Flow Diagram with Intermediate Goods

4.5 Rest of the World

California is an open economy, which means that it trades goods, services, labor, and capital readily with neighboring states and countries. In this model, all agents outside

California are modeled in one group called "Rest of World (ROW)." No distinction is made between the rest of the U.S. and foreign countries. California interacts with two types of agents: foreign consumers and foreign producers. Taking the producers first, Figure 3 below shows that the producers sell goods on the (final) goods-and-services markets and on the intermediate markets, i.e., they sell goods to both households and firms. The model takes these goods as being imperfect substitutes for the goods made in California. Agricultural products from outside of California (e.g., feed grains, bananas) are taken as being close to, but not identical to, California-grown products (e.g., avocados, fresh chicken). The degree to which foreign and domestic goods substitute for each other is very important. Foreign households buy California goods and services on the goods-and-services markets. They and foreign firms both can supply capital and labor to the California economy, and domestic migration.

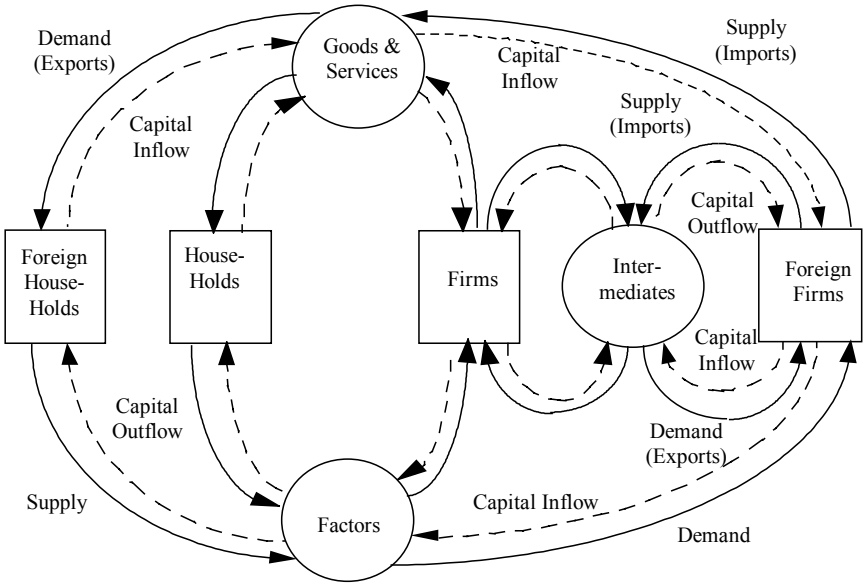

Figure 3 The Circular-Flow Diagram with Intermediate Goods and Trade

4.6 Government

Finally, government is considered. Combining the taxing and spending effects of the three levels of government (federal, state, and local) gives the additional flows in Figure 4 below. Beginning at the top, the figure shows that government buys goods and services and gives up expenditure. It supplies goods and services for which it may or may not receive revenue. Government also supplies factors of production, such as roads and education. The model does not currently include goods such as K-12 education as such goods are not always traded in organized markets. Government also makes transfers to households, which are not shown in the diagram. The middle section of the diagram shows the myriad of ways in which government raises revenue through taxation.

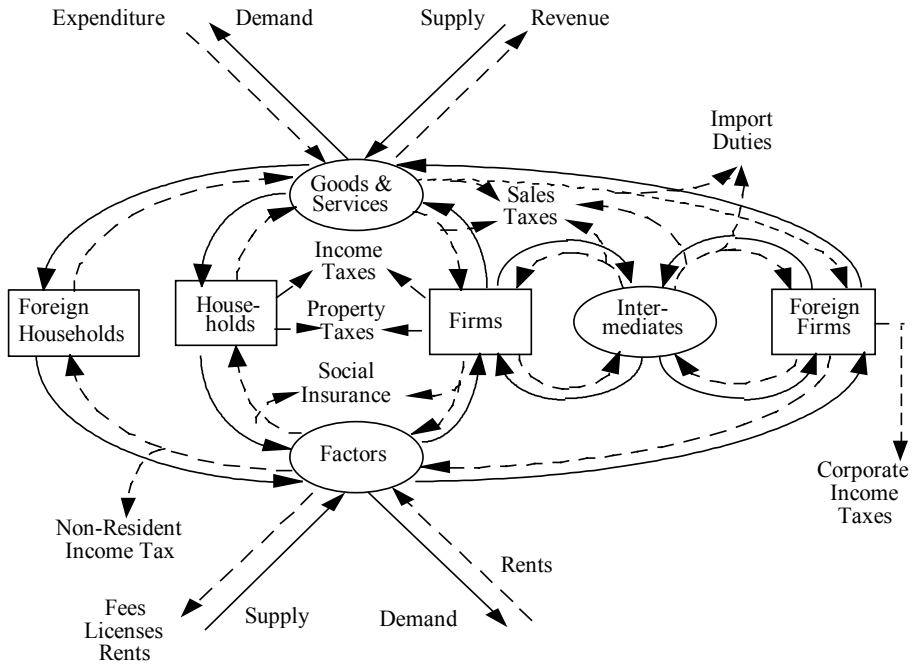

Figure 4. The Complete Circular-Flow Diagram

4.7 Data Organization: The Social Accounting Matrix

The first step in constructing a CGE model is to organize the data. The traditional approach to data organization for a CGE model is to construct a Social Accounting Matrix (SAM). A SAM is a square matrix consisting of a row and column for each sector of the economy. Each entry in the matrix identifies an exchange of goods and services purchased by one sector from another sector (or itself). The entries along a row in the SAM show each payment received by that particular row sector from each column sector. Summing across the row gives total payments made to that row sector by all column sectors. The entries down a column in the SAM show the expenditures made by that particular column sector to all row sectors. Summing down a column gives total expenditures by that column sector to all row sectors. For accounting purposes, a SAM must "balance," i.e., each row sum and corresponding column sum must be equal. This balancing ensures that no money "leaks" out of the economy, i.e. that all money received by firms (row sum) is spent by them (column sum).

5. Overall Economic Impact Estimates

Higher vehicle prices associated with the proposed regulations would affect the California economy through many complex interactions. E-DRAM was developed to simulate many of these complex interactions. Using the model, ARB staff in

consultation with UC Berkeley researchers conducted an assessment of the economic impacts of the proposed regulations on the California economy.

The changes caused by the proposed regulations will affect industries both negatively and positively. The net effect on the California economy of these activities hinges on the extent to which products and services are obtained locally. Using the E-DRAM model of the California economy, staff estimated the net effects of these activities on affected industries and the overall economy. The California industries and individuals affected most by the proposed climate change regulations are those engaged in the production, distribution, sales, service, and use of light-duty passenger vehicles as well as the refining and distribution of gasoline.

Tables 7, 8, and 9 summarize the impacts of the proposed climate change regulations on the California economy for fiscal years 2010, 2020, and 2030 respectively. Since the E-DRAM model is built to reproduce the economic conditions of fiscal year 1998/99, we first extrapolated the model out to 2010 based on State population, personal income, and industry-specific forecasts[5]. Higher vehicle prices were then adjusted to fiscal year 2010, 2020, and 2030.

The results of the E-DRAM simulation show that the changes caused by the proposed regulations would reduce the California economic output by roughly $40 million (0.002 percent) in 2010, $2.5 billion (0.08 percent) in 2020, and $4.8 billion (0.1 percent) in 2030. Personal income, however, would increase by roughly $160 million (0.01 percent) in 2010, $5.3 billion (0.3 percent) in 2020, and $8.5 billion (0.3 percent) in 2030. As a result, California net employment impact due to the proposed regulations would also increase by over 3,000 jobs (0.02 percent) in 2010, 55,000 (0.3 percent) in 2020, and 83,000 (0.4 percent) in 2030.

Table 7. Economic Impacts of the Proposed Climate Change Regulations on the California Economy in Fiscal Year 2010

California Economy	Without Climate Change Regulations	With Climate Change Regulations	Difference	% Total
Output (Billions)	$2,228.06	$2,228.02	- $0.04	- 0.002
Personal Income (Billions)	$1,451.01	$1,451.17	+ $0.16	+ 0.01
Employment (thousands)	16,354	16,357	+ 3	+ 0.02

[5] For a more detail description of the E-DRAM extrapolation to "out years", see "Benefits of Reducing Demand for Gasoline and Diesel," a joint report to California Air Resources Board and California Energy Commission prepared by Arthur D. Little, Inc., March, 2002.

Table 8. Economic Impacts of the Proposed Climate Change Regulations on the California Economy in Fiscal Year 2020

California Economy	Without Climate Change Regulations	With Climate Change Regulations	Difference	% Total
Output (Billions)	$3,078.02	$3,075.49	- $2.53	- 0.08
Personal Income (Billions)	$2,009.54	$2,014.81	+ $5.27	+ 0.3
Employment (thousands)	18,661	18,716	+ 55	+ 0.3

Table 9. Economic Impacts of the Proposed Climate Change Regulations on the California Economy in Fiscal Year 2030

California Economy	Without Climate Change Regulations	With Climate Change Regulations	Difference	% Total
Output (Billions)	$4,241.54	$4,236.71	- $4.83	- 0.1
Personal Income (Billions)	$2,781.44	$2,789.91	+ $8.47	+ 0.3
Employment (thousands)	21,763	21,846	+ 83	+ 0.4

These results indicate that higher vehicle prices cause consumers to redirect their expenditures. Consumers would spend more on the purchase of motor vehicles, thus having less money to spend on the purchase of other goods and services. Since most automobile manufacturing occurs outside of the State, the increased consumer expenditures on motor vehicles would be a drain on the California economy. The reduction in operating costs that results from improved vehicle technology would, however, reduce consumer expenditures and would therefore leave California consumers with more disposable income to spend on other goods and services. Businesses that serve local markets are most likely to benefit from the increase in consumer expenditures. The increase would in turn boost the California economy, resulting in the creation of additional jobs.

In the context of the State's economy, the economic impacts of the proposed regulations are small and are not expected to impose a noticeable impact on the California economy. However, the proposed regulations are expected to take an important step towards promoting economic benefits to Californians in many areas such as public health, water supply, agricultural productivity, environmental degradation, and catastrophic natural disasters. These benefits, which are difficult to quantify, are not included in this analysis. Overall, implementation of the proposed regulations would be expected to improve the well-being of Californians.

6. Potential Impact on a Typical Low-income Household

The proposed climate change regulations are likely to require changes in vehicle technology that could increase the price of new vehicles sold in California. This increase in turn is expected to increase the price of used vehicles. These changes have the potential to adversely affect low-income purchasers of used vehicles. Although the improvement in vehicle technology is expected to lower the fuel usage of new vehicles, these vehicles will not be available in the segment of the used car market that is most attractive to low-income purchasers. According to the 2001 National Household Travel Survey, low-income households with an average annual income of $20,000 tend to purchase vehicles with an average age of 10 to 12 years[6]. Thus, it is not expected that low-income households will typically purchase vehicles impacted by the regulations for sometimes to come.

6.1 Approach

The study approach used to assess the potential impact of the proposed regulations on typical low-income purchasers of used vehicles is outlined as follows:

(1) Changes in prices of used vehicles caused by the proposed regulations for typical PC/LDT1 and LDT2 were estimated, using historical retention value for various vehicles and trucks. For example, a $500 increase in the price of a PC/LDT1 is expected to increase the price of a 10-year-old vehicle by $115 assuming a retention value of 23 percent.

(2) Changes in prices of used vehicles were annualized over the remaining life of vehicles. For example, an $115 increase in the price of a 10-year-old PC/LDT1 is equivalent to a $22 annual cost increase for the vehicle over its median remaining useful life of 8 years.

(3) Annualized cost increase was compared with median income of typical low-income households to assess the extent of the impact on typical low-income household purchasers of used vehicles.

[6] 2001 National Household Travel Survey, the U.S. Department of Transportation, http://nhts.ornl.gov/2001/html_files/introduction.shtml

6.2 Assumptions

The following assumptions were used to estimate the potential economic impacts of the proposed regulations on typical low-income households:

(1) The proposed regulations would increase the average price of a PC/LDT1 by about $630 and the average price of a LDT2 by $960.

(2) Most low-income households purchase vehicles that are at least 10 years old. This assumption is based on the information obtained from the 2001 National Household Travel Survey.

(3) A 10-year-old used PC/LDT1 has retention value of about 23 percent. A 10-year-old LDT2 has retention value of about 32 percent. This information is generated from the depreciation schedule used by the CABITIS model.

(4) A Real discount rate of 10 percent was used for this analysis. The inflation adjusted interest rate on car loans was about 5 percent in the past 10 years[7]. A 5 percent risk premium was added to the historical car loan rate to reflect higher risk associated with financing used vehicles and lending to low-income households.

(5) New small or large vehicles are expected to have the median useful life of 16 years, and new small and large trucks and minivan have the median useful life of 19 years[8]. Based on the data from EMFAC, a 10-year-old car has a median remaining useful life of 8 years and a 10-year-old truck with a median remaining useful life of 11 years.

(6) California households of three with the annual family income of $15,000 or less are considered to be economically disadvantaged[9].

(7) Low-income households do not experience savings from reduction in fuel consumption at least in the first 10 years of the proposed regulations.

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[7] Historical car loan data, Federal Reserve Statistical release,
http://www.federalreserve.gov/releases/g19/hist/cc_hist_tc.html
Historical Consumer Price Index, U.S. Department of Labor, Bureau of Labor Statistics,
http://research.stlouisfed.org/fred2/data/CPIAUCNS.txt

[8] Please see "Draft Technology and Cost Assessment for Proposed Regulations to Reduce Vehicle Climate change Emissions Pursuit to AB 1493," Air Resources Board.

[9] U.S. Census Bureau, Poverty 2003

6.3 Results

Typical California low-income households are affected by the proposed climate change regulations to the extent that the implementation of the regulations would alter their annual income. Using the above assumptions, staff estimated that the increase in annual costs of used vehicle ranges from 0.2 to 0.3 percent of the annual family income of $15,000 for a low-income household, as shown in Table 10. This represents a minor change in the average income of typical low-income households.

The above analysis assumes that low-income households would be able to finance the increase in used car prices either from their own income or from borrowing. As shown in Table 10, the increase in used car prices would be $145 for a PC/LDT1 and $307 for a LDT2. It is, thus, possible that some low-income households might have difficulty raising additional money to purchase their vehicles. We believe this case is highly unlikely because about 70 percent of vehicles owned by households with family income of less than $15,000 is passenger cars[10]. These households are likely to replace their vehicles with similar vehicles. Therefore, the additional costs of used cars to most low-income households would be about $145. This amounts to about 0.2 percent of their annual income.

Table 10. Potential Cost Impacts on Low-Income Households

Description	PC/LDT1	LDT2
Increase in New Car Prices	$630	$960
Increase in Used Car Value	$145	$307
Median Remaining useful life (years)	8	11
Annualized Cost	$27	$47
Poverty Income Level	$15,000	$15,000
% Change	**0.2**	**0.3**

6.4 Potential Benefits of the Proposed Regulations

The proposed regulations may cause vehicle prices to increase, but the low-income purchasers of used vehicles are not likely to face the price increase for several years. When they do pay higher prices for their vehicles, they would experience a significant reduction in vehicle operating costs. The operating cost savings are expected more than offset the increase in the purchase prices. Table 11 provides estimates of the fuel savings for typical low-income purchasers of 10-year old PC/LDT1 and LDT2. The VMT is estimated using EMFAC accrual rates for 10-year-old vehicles and discounting by 20 percent to reflect the fact that low-income consumers tend to drive somewhat less than the average for the population[11]. Data on baseline fuel use and reduction in fuel use

[10] 2001 National Household Travel Survey.
[11] 2001 National Household Travel Survey.

were obtained from the ARB technical and cost assessment report. The table shows that the annual operating cost savings exceed the annual vehicle cost increase. If gasoline prices increase to $2.30, the cost coverage is even greater. Given the wide margin of savings to costs, staff believes that the regulation is highly unlikely to have an adverse effect on low-income purchasers of used vehicles.

Table 11. Impact of the Climate Change Regulations on Low-Income Households

Description	PC/LDT1	LDT2
Average Annual Vehicle Miles Traveled (VMT)	11,200	10,900
Low-income Household VMT	8,960	8,720
Baseline Fuel Consumption (gal/mi)	0.0348	0.0495
Baseline Fuel Use (Gallons)	311.8	431.6
% Reduction in Fuel Use	31.2	22.9
Fuel Savings (Gallons)	97.3	98.8
Gasoline Price (GP)	$1.74	$1.74
Value of Fuel Savings at $1.74 GP	$169	$172
Gasoline Price	$2.30	$2.30
Value of Fuel Savings at $2.30 GP	$224	$227
Annualized Cost	**$27**	**$47**
Benefit-Cost Ratio at $1.74 GP	**6.3**	**3.7**
Benefit-Cost Ratio at $2.30 GP	**8.3**	**4.8**

6.5 Potential Impact on Monthly Loan Payment and Operating Savings

To assess the potential impact of the proposed regulations on the monthly loan payment of typical low-income purchasers of used cars we consider a vehicle-financing period of three years at an interest rate of 10 percent. Table 12 provides estimates of potential increases in monthly payments and fuel savings for the PC/LDT1 and LDT2 categories. As shown in the table, the proposed regulations are expected to increase average monthly payment for a typical low-income household from about $4.68 for a PC/LDT1 to $9.91 for a LDT2. Concurrently, typical low-income consumers would benefit from monthly fuel savings ranging from about $14.11 for a PC/LDT1 to $14.34 for a LDT2 when fuels are priced at $1.74 per gallon. The monthly savings are even higher when fuels are priced at $2.30 per gallon. It should be noted here that most used vehicles still retain significant portion of their values after three-year financing period. These values tend to effectively reduce the increase in monthly payments if they are realized after the completion of the loan payments. Even without the realization of the residual value, monthly savings from vehicle operations exceed the increase in monthly loan payments for all vehicle classes.

Table 12. Potential Impact on Monthly Loan Payment and Operating Savings

Description	PC/LDT1	LDT2
Maximum Increase in Used Car Value	$145	$307
Increase in Monthly Loan Payment	$4.68	$9.91
Monthly Operating Savings at $1.74 GP	$14.11	$14.34
Monthly Operating Savings at $2.30 GP	$18.67	$18.96
Net Savings at $1.74	**$9.43**	**$4.43**
Net Savings at $2.30	**$13.98**	**$9.05**